RECRUITING AND TRAINING BUSINESS-SAVVY SCIENTISTS:

A REFLECTION ON THE CHANGING POLICY OF GRADUATE EDUCATION

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The business of science. To many it seems farfetched that science—especially basic research—and business are intimately inter-twined. Others bristle at the assertion that all forms of science should embrace business concepts. Even after the publicity surrounding *Prey* by Michael Crichton, bringing attention to the commercialization of nanotechnology, many continue to disregard the evidence that science and business are enjoying a renewed period of integration unmatched since the GI Bill redefined post-secondary education.

Consider, for example, the human genome project. What an amazing achievement. The publicly funded International Human Genome Project was started in 1990. But by 1998 only a small fraction of the three billion chemical letters had been spelled out. In May 1998, an upstart scientist, bankrolled by $300 million, formed Celera Genomics with the motto, "Speed matters. Discovery can't wait." A scant two years later, in June 2000 at a much-publicized White House event, the competition between the government-financed Human Genome Project and Celera Genomics was considered a tie—the two groups finished decoding the genome simultaneously. Or that was the story at the time. At the height of the competition Celera was able to raise $900 million in a stock offering. Many would assert that the competition between pure science and the commercial enterprise accelerated the achievement.[1]

On the business education side, there is a growing academic debate about the role of business schools as professional training academies[2] and the benefit/relevance of graduate business education to society in general.[3] The debate centers around the value of business education in the context of societal expectations and the motivation for changing a model that seems heavily influenced by constituencies with conflicting objectives. In this paper some of the issues will be discussed from a policy perspective with regard to science and business, as well as from a reflection on how graduate education expectations have changed over the past 25 years.

How is Graduate Education Changing?

For the public sector scientists of the Human Genome Project, who believed in an openly available genomic code as a guiding principle of the project, their work became accelerated and competitive. The basic research model changed to a time-dependent and outcome-focused activity with specific, or some would assert, strategic, goals. The human genome-mapping project began to develop distinct organizational mission, goals, overall strategy, execution processes, and program evaluation components. Perhaps more importantly, scientists realized that the achievement of their mission—public access to research results—would only occur if they became business-savvy.

Since the early 1980s there has been a growing sense of importance and complexity surrounding the development of basic research, including the opportunities to turn basic research into sources of revenue for universities. In 2000, universities collected over $1.1 billion in royalties from the 13,000 patents they hold. That same year the U.S. Patent and Trademark Office granted 3,272 patents to universities compared to 269 in 1979. Amazingly, Columbia University has received more that $200 million for permission to use one patented process for splicing human genes into living cells to produce human proteins, which are then turned into human drugs.[4]

How important are these numbers to the basic research program? Data from the National Science Foundation shows that over the last five years or so approximately 70 percent of basic research was conducted by universities that in turn led to research and development in commercial firms. However, of the research and development leading to new products, processes and services, industry activity accounts for approximately 70 percent of the publicly-recognized products and services. In fact, when comparing the division of innovation labor between universities and industry overall, a 90/10 pattern becomes evident. That is, only 10 percent of basic research is conducted by industry while universities conduct only 10 percent of innovation development.

In an effort to bridge this gap, the National Science Foundation developed and has continued to fund the Integrative Graduate Education and Research Traineeship Program (IGERT). This program seeks to take a multidisciplinary approach to train scientists and engineers, focusing on two identified needs:

1. facilitation of innovation, and
2. integrating business and external constraining forces, such as legal and regulatory mechanisms, into the development and advancement of innovation.

The IGERT program is now in its sixth year of funding.[5]

With these issues as a broad backdrop, the trends in university graduate education policy can be viewed as having experienced three rather distinct steps. Historically, the outcome of graduate education was expected to result in *education.* This changed around 1970 to a secondary outcome expectation; universities were expected to *educate and train* graduate students by imparting market-beneficial skills. The current expectations from graduate education include *education and integration*. That is, today graduating students are expected to have a broad multidisciplinary perspective *and* a narrow field of expertise. In common terms, we are expected to graduate students who can readily see the forest *and* the trees.[6]

What are the Linking Points to Graduate Education?

In the resource-dependent world of basic research, universities have turned to technology advancement in hopes of funding the business of science. Technology advancement includes the management of extramural funding for specific research initiatives hopefully leading to: innovation, innovation protection, and licensing and commercialization. While it would seem plausible that the latter would be the source of most business skills necessary to benefit the university, many argue that all facets of technology advancement benefit from the integration of business education.

To better visualize the science and business integration in the training of business-savvy scientists and engineers, consider a balance beam with *science* at one end and *business* at the other. At the first step of technology advancement, extramural funding and basic research, the balance beam is weighted heavily on the side of science. Yes, there are certainly business aspects to planning, budgeting, and expending resources with a particular research objective in mind. However, most graduate students and postdoctoral fellows have gained experience in these tasks that reflect the *education and training* expectations mentioned earlier.

The second phase, innovation recognition, characterized by the disclosure of a possible invention begins the questions: What do we have? What is it worth? Who will buy it? At this step, the balance beam is probably level. Market and financial analyses of invention value are conducted. Along with the search for “prior art,” scientists and innovation protection professionals are determining the potential uses and value of the invention.

In the final step, when decisions about licensing and commercialization options are made, the balance beam moves distinctly to the business side. Unfortunately, the steps occur in a rather disjointed manner because the lack of integration between science and business forces different groups to communicate in long and involved ways about the potential value of the innovation. In addition, the relative level of incentive alignment between the scientist and the university are de-coupled. For example, it is rare that a scientist has the personal or professional motivation to develop an in-depth understanding of the market for a particular invention much less the vehicles available for deriving value from the invention. It is much more common for the scientist to focus on publishing the results of the innovation since the majority of existing compensation links measure outcomes in terms of scholarly publication rather than application of the scholarship.[7] The following figure summarizes, in graphical form, some of the issues leading to the shift in the policy of graduate education.

What are the Policy Issues?

The policy issues for graduate education involve the need to train business-savvy scientists and revolve around two basic policy objectives:

- Imparting the skills that will make graduate students successful in industry, and
- Adapting to the changing roles and responsibilities of the university/industry research enterprise.

As the number of commercial enterprises with academic links continues to grow, problems associated with such organizations grow in direct proportion. There are at least four specific policy issues that must be acknowledged for the two policy objectives to occur. The policy issues of most importance seem to be:

1. developing appropriate university support services to assist in innovation value creation,
2. training scientists, engineers, and business students for commercial success in the fast-paced world of innovation advancement,
3. changing the risk/reward philosophy and alignment mechanisms in the university-industry environment, and
4. seeking to balance the capitalization of the research enterprise.

Developing Support Services. Many universities maintain offices of research and/or offices of technology transfer. Even more have established research foundations and commercialization vehicles. Most often these important functional units are somehow connected by interlocking employee duties. There exists a need for the development of integrated resource management processes to speed the flow of resources and assist in decision-making intended to assist the innovation creation, protection, and value generation. It would be a starting point, for example to simply adopt and adapt the resource management processes in place at technology firms such as Motorola, Phillips N.V., Proctor & Gamble, and many other firms that base their competitive advantage on continual innovation. In his recent work, Harvard Business School professor Henry Chesbrough suggests that “open innovation” is the model to be followed when redesigning the university innovation advancement process.[8] His contention is that innovation must be managed inside and outside the university/industry relationship since the most successful efforts, for example the Human Genome Project, seem to follow this model of cooperation and competition.

Training Graduate Students for Commercial Success. As the innovation enterprise described in the previous policy issue becomes a reality, there will increasingly be the need for capable people to participate in and manage the process. This places emphasis on the education and integration aspects of graduate education. It is important for scientists to understand the commercial processes just as it is important for business and law students to understand scientific inquiry, discovery disclosure, innovation protection, and licensing/commercialization processes. How does this begin? From a policy perspective it may occur at two levels. First, it may be initiated through the availability of funded graduate training opportunities, as exemplified by IGERT and similar programs. Second, and perhaps along a longer time line, is the development of multi-disciplinary teams of faculty and industry representatives operating in the open innovation model suggested by Chesbrough.

Changing the Reward Structure. From an academic standpoint, many of us recognize that peer-reviewed publication and extramural funding are strongly linked to desirable personal outcomes such as annual salary increases, reduced teaching responsibilities, additional resources, tenure, and promotion. Limited survey evidence shows that almost all research-focused commercial firms pay the inventor for patent filing, patent issuance, strategically important patents, and longevity in the patent "game." However, very few, if any, universities specifically reward inventors for these activities. Typically, universities share the royalties with the inventor after all the innovation value creation is completed—many times without significant involvement of the inventor. My own limited research into the relationship between telling someone what is important, developing a clear link to short term rewards for desirable behavior, and longevity in office (tenure) indicates that specific short term financial rewards, or as we call it—carefully coupled inventive alignment—overwhelms the simple effects of monitoring employee behavior.[9] How strong is the effect and how much incentive is necessary? Empirical research has shown that relatively small levels of incentive compensation result in aggressive changes in behavior. In industry, the typical award for patent filing is approximately $1000 with another $500 or so awarded upon patent issuance. Clearly, changing the reward structure at the university level is an important and far-reaching policy matter.

Balancing the Capital Needs. Perhaps one of the most basic facts about business is: Cash is king. That is, it takes cash to grow businesses of any type. This includes the innovation enterprise underlying the policy shift in graduate education. Capital needs can be grouped into two policy areas. First, there is the short-term need to establish funds to reward innovation creation and protection. Second, funds will be needed to pay for the infrastructure, staff, and start-up costs related to innovation value creation. Imagine the impact on the speed and effectiveness of innovation value creation if business-savvy scientists were involved in the advancement of their own innovation. As a policy matter, the allocation of extramural funding to pay for innovation creation must be balanced with the costs associated with innovation protection and value creation. Until now, most of the process has been loosely linked—the rousing successes are few and far-between. Changing the success rate will undoubtedly make a difference in how universities are able to change the nature and policies impacting graduate education.

End Notes

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Innovation Creation, Protection & Value Development